THE VALUE OF OAK LEAVES FOR FORAGE.

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During the summer and fall of 1903, while experting a forest reserve in the north Coast Ranges, the writer noticed with surprise and interest the eagerness with which leaves of certain oaks were eaten by live stock. Having this fact in mind, many observations were made in regard to the forage value of each species of oak occuring in the Coast Ranges. These observations, while confined more especially to the extent to which each species was eaten by stock, included also the range os distribution, altitude, and mode of occurence.

Later in the year, in order to ascertain if possible whether these observations indicated fully the real value and significance of these oaks for forage, a chemical analysis was undertaken covering six species of oaks and one of poison oak. Only those species were chosen which occur on hills, ridges, and mountains where tillage is impossible; and the object kept continually in mind was the forage value of the leaves of the different species.

It is the purpose of this paper to give in full the results of both observation and analysis, and to discuss the harmony or lack of harmony between the two.

BOTANICAL SURVEY.

The Ranges covered by the investigation are those situated in

Lake County above Clear Lake, in eastern Mendocino County above Ukiah to Humboldt County, in the western parts of Colusa and Glenn Counties, and in southwestern Tehama County. This area is typical of all the North Coast Ranges, and, in regard to oaks, may be taken also as a type of the South Coast Ranges. Thus the browsing areas of the Coast Ranges alone cover about one-third of the State. Adding to these, those areas of the lower Sierra foot-hills which are covered by many of these same species of oaks, we have, as the entire region enriched by browsing oaks, about one-half the State area.

The six species of oaks and the poison oak, (a species of Rhus), chosen from this browsing area for investigation and discussion here are all exclusively Californian and peculiar to the State with the one exception of Quercus Garryana, which crosses south from Oregon in the Coast Ranges.

Each of these oaks varies in range according to temperature, altitude and humidity; and the value of each species as a "browse" increases almost directly with the altitude, except when modified by exposure to the direct rays of the sun. Beginning on the lower hills, the six species succeed one another in nearly distinct zones or ranges, as follows:-

Blue Oak,(Quercus douglasii,) Scrub Oak and Curl-leaf Scrub Oak,(Q. dumosa and its variety, revoluta,) Canyon Live Oak, (Q. wislizenii,) Maul Oak, (Q. chrysolepis), Black Oak, (Q. californica), and White Mountain Oak, (Q. garryana).

In addition to these, the poison-oak, (Rhus diversiloba), is found commonly everywhere, on hills, slopes, and by streams.

The following description will attempt to characterize each individual species in the above order, as regards form, mode of occurrence, range, and the forage value as indicated by the stock feeding upon it.

BLUE OAK (Quercus douglasii).

The Blue, or Rock, Oak, (Quercus douglasii), reaches, in favored localities, a height of 20ft., but is commonly found as a small tree about 12 feet high, or as a shrub from 4-6 feet in height It is oval or round in appearance and is covered densely with dark bluish leaves. The leaves are obovate to oblong with lobes commonly indreasing in size toward the apex. In young trees and shrubs the leaves are inclined to become spinescent. The acorns, borne in shallow cups, are oval to ovate-acute and are about 1 to 1-1/2 inches long.

In altitude, this oak is limited to the low foothills and dry valleys where the soil is hard and rocky, and never ranges upward to the higher slopes and valleys. It is found most abundantly in the dry foothills of the inner Coast Ranges, but has a complete range from Mendocino County and the upper Sacramento valley through the Coast Ranges and Sierra Nevada to Tejon Pass, from whence stunted individuals extend to the margin of the Mojave Desert.

Quercus douglasii. (Blue or Rock Oak).
In its natural range on Eel River, Lake County.
Bloody Rock, where the last of the
Chumiah Indians perished.


Herb. University of California
California

On account of the dryness of its leaf, only goats and sheep browse on the Blue Oak; but the mast, which is plentiful and quite certain, is excellent feed for hogs, cattle, sheep, goats, and often for horses.

SCRUB OAK. (Quercus dumosa).

This oak is a round topped shrub 5 or 6 feet high, consisting of numerous closely tangled branches starting from near the ground. The twigs are usually tormentose with leaves bunched at the ends. The leaves are oblong to obovate and entire in the older trees, but are often sinuate-toothed and spinescent in young shrubs. They are pale green in color and pubescent on the ventral side. The acorns are oval and pointed, from 1/2 to 1-1/2 inches long, and are contained in shallow cups. The crop is light and very uncertain.

The Scrub Oak is commonly found associated with many other shrubs in the Chaparr l of the mountains and upper foothill slopes in dry localities. It ranges from Mendocino County southward through the Coast Ranges to Lower California, and is also found in the foothills of the Sierra Nevada.

This shrub, on account of its low habit of growth is particularly adapted to browsing, and is one of the best for sheep and goats. Cattle, however, dislike it on account of its harsh spinescent leaves, but feed on it during the winter when snow has covered the ground, or when for any reason other food is not available.

Quercus dumosa. (Scrub Oak).

Quercus dumosa var. revoluta.

(Curl-leaf Scrub Oak).

CURL-LEAF SCRUB OAK, (Quercus dumosa var. revoluta).

(Q. dumosa, variety revoluta,) is a variety of the species with the same shape of brush and habit of growth. The leaves differ, however, in having the margins strongly revolute, thus presenting a curled appearance. The underside of the leaf is densely tomentose, and the whole leaf is thicker and rounder than that of the species. The acorns of the variety are similar in size and shape to those of the species, but are contained in even shallower cups.

This oak is seldom found south of San Francisco Bay, and reaches its greatest abundance north of Clear Lake on the dry eastern slopes of the Coast Ranges bordering on the Sacramento Valley and extending to Mt. Shasta.

The forage value of the variety is apparently the same as that of the species.

CANYON LIVE OAK, (Quercus wislizenii).

Canyon Live Oak, (Quercus wislizenii,) when found in the canyons is a tree usually 20-40 feet high, but when it passes into the chaparral, it is never higher than 8 feet. Here it is an intricately branched shrub with a round top. The bark on old trees is rough and thick, but on shrubs it is smooth. The leaves are usually oblong-lanceolate, entire, serrate or dentate, and are lustrous and dark green in color. They are about 1-1/2 inches long and 3/4 of

Quercus wislizenii. (Canon Live Oak.)

an inch wide. The nuts ripen in the second season, and are long, sessile, slender oblong oval, set in deep scaly cups. The mast is usually scanty.

The shrub is common in the chaparral with the Quercus dumosa and ranges with it in altitude. It is well distributed in the Coast Ranges from Mt. Shasta to San Bernardino, usually at quite a distance from the sea. It also exists, but not commonly, from Mt. Shasta through the lower foothills of the Sierra's to Tejon pass.

The leaves of this shrub are sought in preference over those of the Scrub Oak by sheep, goats, and cattle, and it is thus often found stripped of its leaves.

MAUL OAK. (Quercus chrysolepis).

(Q. chrysolepis) when found growing on well watered and protected slopes, is a tree 40-60 feet in height, with large sweeping branches. On exposed slopes, however, and on the upper ridges and peaks, it becomes a gregarious shrub with Q. garryana. The leaves are oblong, acute, or cuspidate, entire on old trees but spinose-dentate on young ones and on shoots. They are pale and glaucous above, with golden tomentum below. The acorn is usually solitary, ovate or oval, 1/2 to 2 inches long, and borne in a shallow cup. The crop of mast is uncertain and is often ruined by the larvae of moths.

The range of this oak extends from Southern Oregon through

Quercus wislizenii. (Canon Live Oak.)

the Coast Ranges and Sierra Nevada and on through the San Bernardino Mountains to Lower California. It often reaches elevations of 9000 feet.

Maul Oak is used as a "browse" by sheep and goats and sparingly by cattle.

BLACK OAK. (Quercus californica).

Quercus californica is a tree, 18 - 30 feet high, with several large erect branches. It is found usually near coniferous trees and apparently occupying the same belt. Young trees often occur in dense growth, and, when in this condition or when overshadowed by other trees, grows slowly, thus enabling stock to browse on them. The leaves of young trees are covered with a dense grey tomentum below, and are pubescent above. On older trees the leaves are glabrous with littel tomentum. In shape, they vary from oblong to broadly ovate in outline, and each consists of about seven lobes. The nut is broadly ovate, one inch in length, and ripens in the second season. The crop is scanty and unreliable.

The range of the Black Oak extends from the Mckenzie River in Oregon through the Coast Ranges and Sierras and through the San Bernardino Mountains to Lower California. This oak often reaches elevations of 7000 - 8000 feet. It is scarce near the coast.

The flexible texture of the leaves of this oak allows it to be easily eaten by cattle and horses as well as by sheep and goats.

Quercus californica (Black Oak).

WHITE MOUNTAIN OAK, (Quercus garryana),

This species is divided into two sorts, differing only in range and height of individuals. The typical kind is a tree, 30-70 feet in height, with erect rigid branches. Its leaves are oblong to obovate, 4 to 8 inches long, with coarse lobes. The acorns are sessile or shortly pedunculed, oval to slightly obovate, about 1-1 1/4 inches in length, contained in a shallow cup.

It ranges from Vancouver's Island southwestward through western Washington, Oregon, and the Coast Ranges of California.to Santa Cruz. It is the only oak used for lumber on the Pacific Coast, and furnishes the oak lumber for the furniture factories of West Berkeley.

The other form of this species is a mere shrub from 2-6 feet high, but identical with the larger form in every other particular.

Its range begins in an exposed portion of western Washington, where apparently it is stunted by the severe sea-breezes. Passing along the western slopes of the Cascades in Washington and Oregon, its elevation continually increases until in California it is found only on the highest ridges and peaks. Its southernmost range is snow Mt. in Lake County.

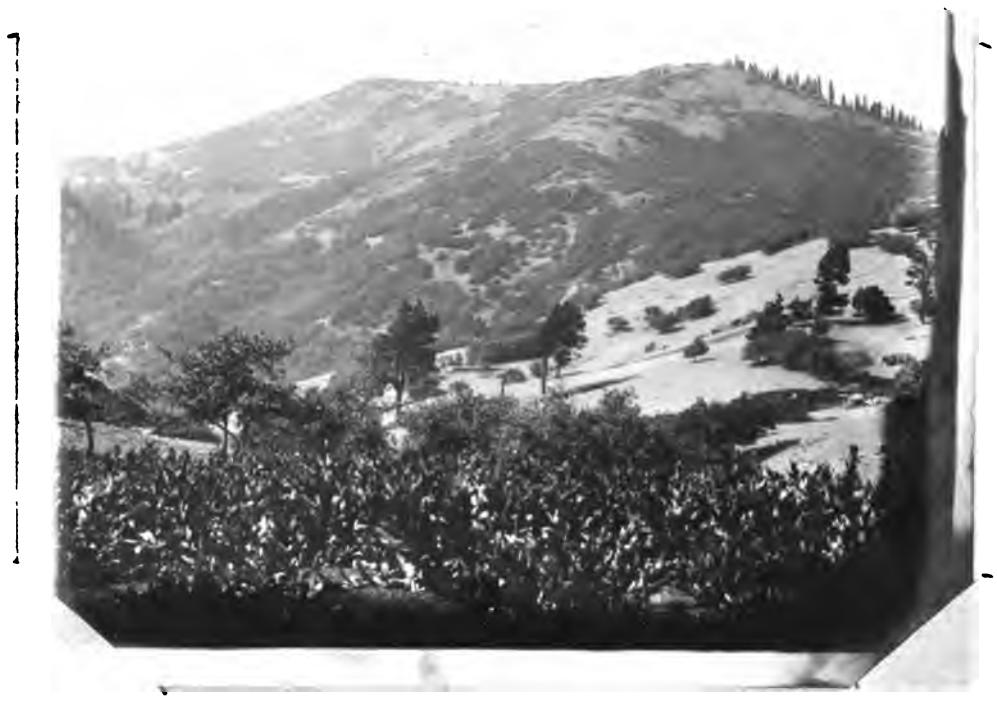
The entire range of this oak is swept by cold driving north winds which apparently serve to keep the same temperature and other conditions throughout.

It is to this form of the Q. garryana that stock men turn when seeking "browse" in their mountain pasture. It is gregarious

Quercus garryana. (Mountain White Oak).

Sanhedrin Mountain in Western Mendocino County.

Showing Quercus garryana pastures and bare places and erosion caused by over pasturing with sheep.



Signal Peak in eastern Mendocino County.

Slopes covered with low growing Quercus garryana and open places where covering has been killed by sheep. In the foreground is False Hellebore, (Veratrum) always an indication of spring water.

over hundreds of acres on the ridges, peaks, and higher slopes in the most exposed places of the North Coast Ranges. It forms thickest to the exclusion of everything else except Quercus Chrysolepis, occasionally, Wild Cherry, (Cerasus).

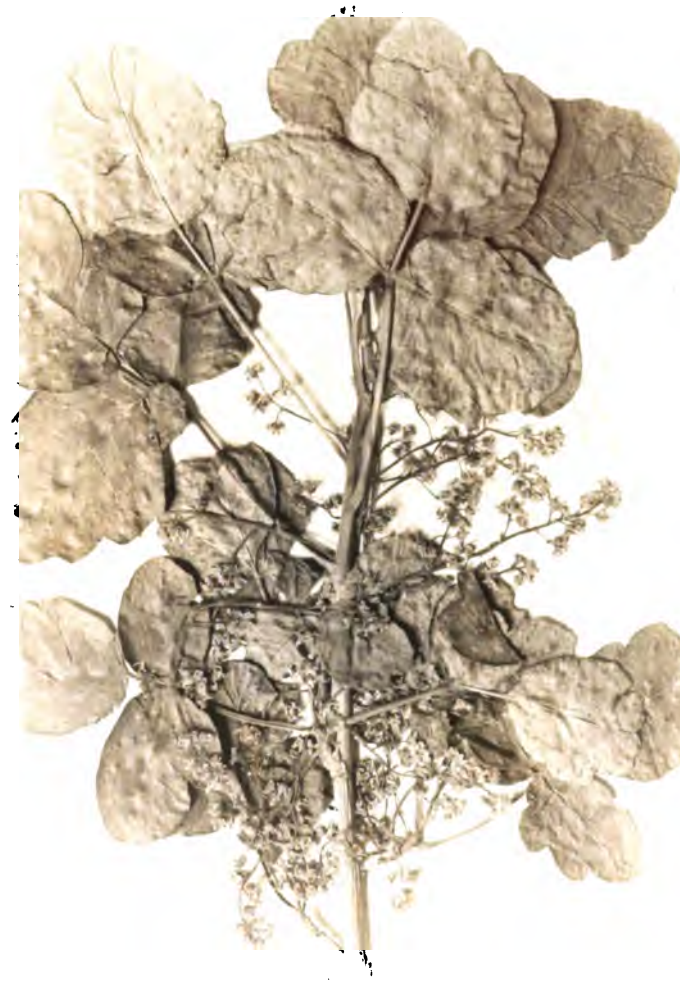
This species, almost unaided, pastures thousands of sheep and goats as well as cattle and horses, and not only keeps them up but actually fattens fattens them. The stock keep whole ranges of it eaten down often to less than within two feet of the ground. Aside from the value of the leaves, the acorn, which is quite sweet, forms a rich diet for stock. The mast is usually sure and abundant.

POISON OAK, (Rhus diversiloba).

Poison Oak (Rhus diversiloba), is usually a small shrub from 2 to 5 feet high, but ocassionallt it ascends the trunks of trees as a vine to a height of 15 or 20 feet. The leaflets are orbicular to ovate, glaucous, with distinct venation. They contain an irritating and poisonous volatile oil which poisons many persons by simple contact or even by diffusion in the air. The fruit is pale, about three lines thick, and quite abundant.

Rhus diversiloba is everywhere common through the hilly portions of California.

In the ranges the leaves and berries are readily eaten by sheep, goats, and horses, but not by cattle as far as could be as-



Rhus diversiloba. (Poison Oak).

certained by observation and numerous inquiries. Many of the bushes are stripped entirely of leaves long before they would naturally drop them.

In summing up the value of these California oaks, the common classification into "live", or evergreen, and deciduous will be made. The former class includes Scrub Oak and Curl-Leaf Scrub Oak, (Quercus dumosa and variety revoluta) Canyon Live Oak, (Q. wislizenii), and Maul Oak, (Q. chrysolepis). The deciduous oaks consist of Blue, or Rock, Oak, (Q. douglasii), Black Oak, (Q. californica), and Mountain White Oak, (Q. garryana). The Poison Oak, (Rhus diversilaba), is also deciduous.

The live oaks, as seen in the previous descriptions, occupy the brush areas on the slopes and ridges, and, except for a few isolated specimens of Quercus chrysolepis, never grow within the timbered, or coniferous, belt. These live oaks, therefore, occupy a continuous belt of country which is free from snow except for occasional short periods. This belt, therefore, is used as a winter range for holding over stock when feed is scarce in the valleys and the deep snows cover the mountains. Sheep and goats are kept in good condition on these live oaks, but cattle and horses do not eat them to any extent until other food cannot be obtained. Then this "browse" keeps them in feed until other is available.

The deciduous oaks, not taking into account the Quercus doug-

lasii which is of little forage value, are found in the timber belt or above it. The leaves of the deciduous oaks, in contrast to the harsh spinescent ones of the live oaks, are larger, lobed and soft. This enables cattle and horses to eat them with ease, and as is also true of sheep and goats, they actually fatten on the leaves of the Black Oak and White Mountain Oak of these upper ridges and peaks.

From the observations just recorded concerning these several species of oaks, it would seem that the nutritive value increases with the altitude. To verify this, and to ascertain if possible their relative food values, a chemical analysis of each species was made.

For the purpose of this analysis the leaves were gathered during the month of September when they were fully mature. Only those which were green and vigorous were taken. These were dried in a room of ordinary temperature, and were then ground to a fine powder.

In gathering the Poison Oak, (Rhus diversiloba), the writer was badly poisoned even though gloves were worn. After drying at ordinary room temperature, the leaves were pressed into the mill with bare hands and no poisonous effects followed. Thus it would seem that the irritating and poisonous oil of this plant is volatile at a comparatively low temperature.

In the analysis of these oak leaves, the analysis of foods

as set forth in Bulletin 46, Bureau of Chemistry, U.S.D.A., was followed. In this analysis, however, certain errors appeared in the ether extract and in the nitrogen free extract. These errors were due to certain peculiarities of composition of the oaks.

In the determination of fat, or ether extract, quantities of chlorophyll, the green coloring matter in the leaves, remained in the extract. No quantitive method being known for the extraction of chlorophyll, this, together with the gums and resins which are contained within the leaves or on the tomentum and pubescense of the outside, increased the ether extract beyond its true percentage.

After determining the nitrogen-free extract, which consists of sugar, starch, pentosans, etc., the percentage appeared inexplicably high. The only possible explanation seemed to be that the tannin content, which, by the method of difference, falls in this group, had not been accounted for. It was necessary, then, to make an analysis for tannin.

In determining the tannin, the method of Günther was followed; that is, two grams of the substance to be analysed was taken and the tannin extracted with hot water, in which it is easily soluble, until a dilution of 1 to 400 parts was obtained. This dilution is necessary in order that potassium permanganate may completely oxidize tannin in the presence of indigo-carmine. The oxidizing power of the indigo-carmine was determined by extracting

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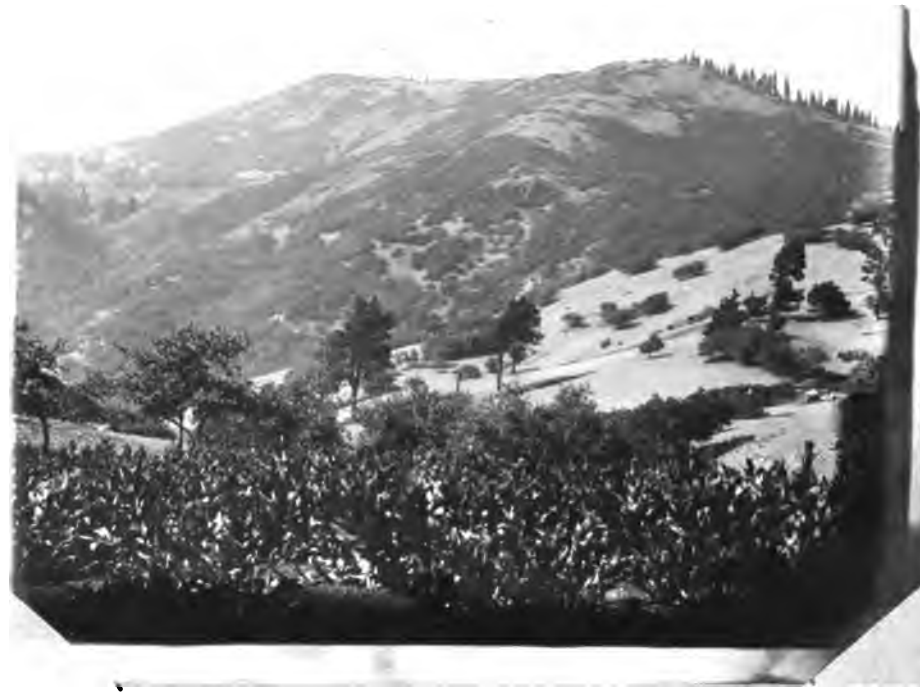

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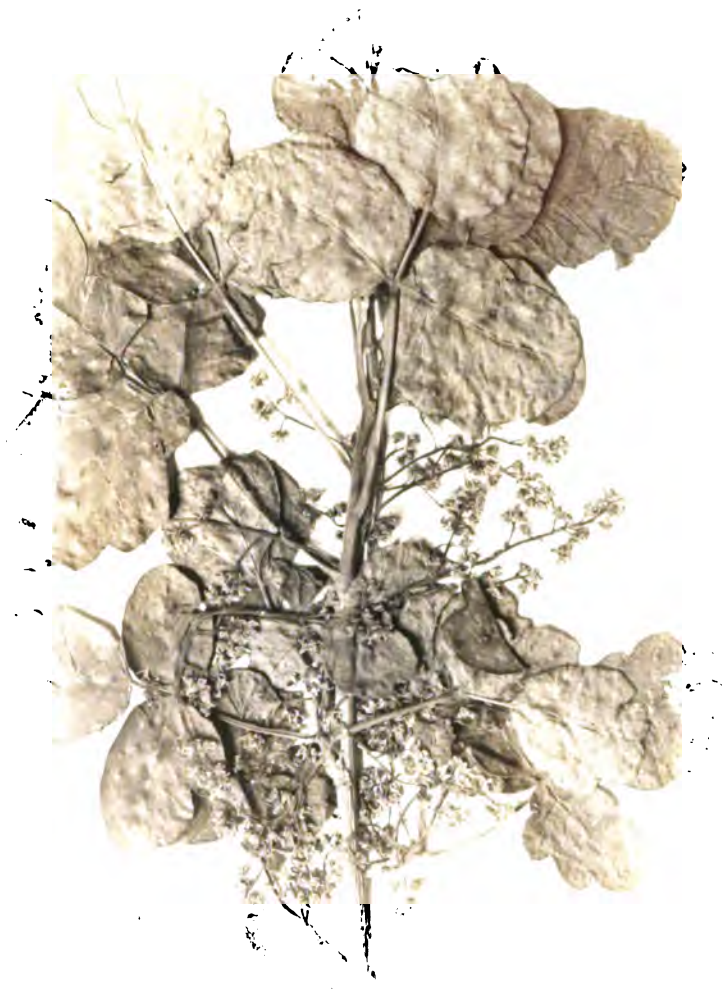

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With these exceptions in the ether extract and the nitrogen-free extract, the regular official method was follows; and the succeeding table gives the results of the analysis of the different species of oak in an air-dry condition. As a means of exact comparison, these results were calculated first to a water-free basis, and finally, to an alfalfa hay basis. The analyses were all carried out in duplicate and the averages taken as follows:

ANALYSES OF OAK LEAVES.

Samples Air Dry.

Species	H_2O %	Ash %	Protein %	Fibre %	Tannin %	N-Free Extract %	Ether Extract %
Quercus douglasii	5.21	9.32	8.32	35.35	5.00	34.55	4.25
" dumosa & variety	3.90	9.42	9.16	26.79	14.06	31.41	5.26
" wislizenii	3.54	9.66	10.95	29.48	9.62	30.89	5.86
" chrysolepis	6.53	9.62	8.32	30.35	10.16	31.52	3.50
" californica	5.10	9.35	8.15	19.23	10.62	40.50	7.06
" garryana	4.59	9.44	15.05	16.26	9.01	40.18	5.47
Rhus diversiloba	5.39	8.86	6.85	25.13	6.42	41.05	6.50

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Water-free.

Species	H_2O	Ash	Protein	Fibre	Tannin	N-Free Extract	Ether Extract
	%	%	%	%	%	%	%
Quercus douglasii		9.85	8.78	35.18	5.28	36.45	4.48
" dumosa and variety		9.80	9.53	27.88	14.63	32.69	5.47
" wislizenii		10.02	11.35	30.56	9.97	32.02	6.07
" chrysolepis		10.29	8.90	32.47	10.89	33.73	3.74
" californica		9.85	8.59	20.25	11.19	42.68	7.44
" garryana		9.90	15.77	17.04	9.44	42.11	5.73
Rhus diversiloba		9.15	7.24	26.56	6.79	43.39	6.87

Water on Alfalfa Basis.

Quercus douglasii	10.95	8.75	7.83	31.32	4.70	32.46	3.99
" dumosa and variety	10.95	8.72	8.48	24.83	13.03	29.11	4.87
" wislizenii	10.95	8.92	10.11	27.21	8.88	28.52	5.41
" chrysolepis	10.95	9.18	7.92	28.91	9.70	30.08	3.33
" californica	10.95	8.77	7.65	18.03	9.96	38.01	6.63
" garryana	10.95	8.82	14.04	15.18	8.41	37.50	5.10
Rhus diversiloba	10.95	8.15	6.44	23.65	6.04	38.64	6.13
Medicago sativa	10.95	6.45	17.60	22.63	——	39.31	3.08

In the discussion of the chemical analysis of these species, alfalfa hay is selected for comparison because alfalfa seems to be the best and commonest forage plant in California. A comparison with this plant then naturally sets forth the value of oak leaves

for forage to better advantage than a comparison with any other stock feed.

ASH CONTENT.

In comparing the ash content of oak leaves and alfalfa, it is noted that the ash of oaks varies but little in various species. This variation is not more than four-tenths of one percent, while the average ash for all the species is somewhat greater than 8.75 percent. This percentage is 2-1/4 percent greater than in alfalfa hay.

As all the mineral, and hence the bone forming, materials of the plant are in the ash, oak leaves have thus a greater value for growing stock than has alfalfa.

PROTEIN CONTENT.

Proceeding to the protein, or muscle forming, content, greater variations are encountered. The comparison shows alfalfa to contain more than twice as much protein as any of the oaks with the exception of two species, Quercus wislezenii and Quercus garryana. The former averages 10.11 and the latter 14.04 percent. Quercus garryana, therefore, approaches alfalfa closely. The other species, though falling far below alfalfa are not poor in protein. The average is nearly eight percent, which is one-half of one percent higher than oat hay - the best of cereal hays.

These analyses indicate that oak leaves are superior in

muscle forming ingredients to non-leguminous hay; that one species, (Quercus wislizenii), is equal to bur clover hay; and the best species, (Quercus garryana), almost equal to alfalfa hay.

CRUDE FIBRE.

In oak leaves the crude fibre is as variable as the protein, ranging from over 30 percent in Quercus douglasii to 15 percent in Quercus garryana. With the exception of two of the deciduous oaks, Quercus californica and Quercus garryana, the oak leaves are considerably higher in crude fibre than alfalfa. This crude fibre, or roughage, in oaks tends to produce a wide nutritive ration.

ETHER EXTRACT.

The fat, or more correctly speaking, the ether extract, is considerably higher than in alfalfa in all the species, and increases to twice as much in Quercus wislizenii and Quercus californica. This ether extract does not represent pure fat but includes the chlorophyll, waxes, and resins, which cannot be separated from the true fat.

These waxes and resins serve to protect the leaves from drying winds and inclement weather, and usually occur in the tomentum or pubescense which cover some leaves. In some cases, as in Quercus californica, the waxes and resins are distasteful to stock, thus decreasing their forage value.

NITROGEN-FREE EXTRACT.

In oaks the nitrogen-free extract, consisting of starch, sugars, pentosans, etc., does not equal alfalfa in any species; and, in Scrub Oak, falls as far below as 10 percent. This fact indicates a lower fattening and heat producing power than in alfalfa.

TANNIN.

Tannin is an astringent principle found in many plants. Aside from its astringent properties, is is acrid, and therefore offensive to the palates of animals. In the stomach, it precipitates the pepsin and peptones, thus preventing the formation of dextrose and hindering digestion. Great thirst and constriction in the digestive tract usually follows an overdose of it. These effects are not so marked in some tannins as in others for some do not have so great a precipitating power as do others.

In determining the tannins in the oaks, it was found to vary greatly in the different species but did not serve as an infallible indication of the value of the leaves for forage. For example, Quercus douglasii, which is the poorest forage oak analyzed is lowest in tannin, whil Quercus dumosa, a species preferred by sheep and goats contains 13 percent, the largest amount of tannin determined in any one species.

The average of tannin for all the oaks is a little over 10

percent. By tasting the powdered specimens of the various species, the intensity of acridity coincides with the tannin percents. In comparison with oak leaves, alfalfa contains an inappreciable amount of tannin.

WATER.

Although the water content of the oak leaves was placed on an alfalfa hay basis, this does not indicate their true comparison when both are green. Green alfalfa contains eighty percent of water which is from 10 to 20 percent higher than that in the various species of oaks. This shows the oak leaves to be a somewhat more concentrated feed in regard to protein, ash, and nitrogen-free extract, than appears in the comparison on an alfalfa hay basis.

INJURIOUS CONSTITUENTS.

Judging from the results of the chemical analyses of these oak leaves, they would seem to occupy a high place among forage plants. This would be the case were it not for excessive amount of three of the chemical constituents; namely, crude fibre, resins and waxes, and tannin.

The high percent of crude fibre taken together with the low percent of nitrogen-free extract produces a coarser and less nutritious feed than leguminous crops.

The resins have pungent and disagreeable flavors hich rend

them distasteful to stock. A good example of this is seen in the Quercus californica before cited. The leaves of the young trees and shrubs of this species contain no more tannin than those of most of the other species, are only 1-1/3 percent below alfalfa in nitrogen-free extract, have a fair amount of protein, are low in crude fibre, and are large and soft. These qualities should produce a feed superior to oat hay. This is not the case, however, for stock avoid it to a great extent on account of the resins and waxes in the dense tomentum covering the leaves. These waxes and resins serve as a protection against drying winds and severe weather, and all the oaks have more or less of them.

As compared with the crude fibre and resins, tannin of oak leaves, as before stated, is not only bitter and astringent but greatly interferes with digestion.

CONCLUSION.

In summing up the value of the forage oaks, from chemical analysis and observations in the field, the conclusion is reached that the facts observed coincide in most cases with the facts determined by analysis. For instance, the deciduous oaks possess a higher nutritive value than the live oaks and are, as would be expected, more readily eaten by horses, cattle, sheep, and goats. In some cases, however, certain physical conditions modify these relations. This is true in the case of the live oaks. These con-

tain a sufficiently high proportion of nutrients and yet only sheep and goats thrive upon them. This is due to the thick harsh leaves with their spinescent teeth which prevent horses and cattle from successfully eating them.

PASTURING OAKS.

Although all stock prefer the deciduous oaks of the higher altitudes, yet indiscriminate pasturing causes much damage to the forests and ground-cover. When sheep and goats are allowed to browse on the deciduous oaks of the timbered area, they kill by nibbling and trampling, the seedling conifers, kill shrubs by over browsing, and cut up the slopes in trails which become deep gullies during the rainy season. This could be avoided by pasturing the sheep and goats on the "live oaks" of the lower chaparral or brush areas, the only necessary precaution being to prevent too many congregating in one place, thus avoiding too much trampling and gulleying.

Since cattle and horses are unable to thrive on the live oaks, and since they do not browse close enough to kill shrubs, never browse on young conifers, nor cut up slopes by trails, they may profitably be pastured on the timbered areas and on the higher altitudes.

Thus, this oak area, comprising half the whole state, can, by a conservative and well-regulated system of browsing, be made to

- pasture sheep and goats throughout the year, and all stock during the summer months and also during seasons of drought or when winter conditions make other feed inaccessible.

B I B L I O G R A P H Y .

1. - Flora of Western Middle California - Jepson.

2. - Silva of North America - Sargent.

3. - Check List of the Forest Trees of the United States, Their Names and Ranges. - Bulletin No. 17, Bureau of Forestry - Sudworth.

4. - Stock Ranges of Northwestern California - Bulletin No. 13, Bureau of Plant Industry. - Davy.

5. - Feeding of Farm Animals - University of California, College of Agriculture - Bulletin 132 - Jaffa and Anderson.

6. - Feeds and Feeding - Henry.

7. - Official Methods of Analysis Adopted by the United States Association of Chemistry - Bulletin 46, Bureau of Chemistry, U. S. Department of Agriculture.

8. - Plant Analysis - Dragendorff.

9. - Chemie der Nahrungs - Und Genussmittel - König.